

## In-Row<sup>®</sup> RC Cooling of HP C-Class Chassis

By John Bean

### Abstract

High performance blade chassis such as the HP c-Class are alleged to be highly problematic regarding thermal solutions within traditional Data Center spaces. APC has developed in row cooling products, such as the InRow RC, to specifically address such challenges.

### Introduction

In an ongoing effort to address the ever changing thermal issues of mission critical information technology spaces, APC developed the InRow RC Product (ACRC100 and ACRC103). This product is intended for deployment directly in the row of standard EIA-310 IT racks that house information technology equipment. Additionally, when deployed with appropriate APC rack solutions, thermal performance may be augmented with either Hot Aisle Containment System (HACS) or Rack Air Containment System (RACS). While techniques for applying all three (Open Row, HACS, and RACS) are similar, the Rack Air Containment System will be addressed specifically (shown in **Figure 1**). RACS was chosen primarily because the short air distribution paths and reduced air volume makes it the most interesting and challenging scenario when coupled to dynamic high density heat loads.

*Figure 1 – RACS system exploded view*



### Deployment Guidance for Blade Centers

The following special considerations should be used when operating c-Class Chassis in any of the possible InRow cooling architectures supported by the InRow RC.

### Open row architecture

Simply follow APC InfraStruXure Designer Tool recommendations and rules along with all recommendations and requirements contained within the Installation Operation & Maintenance Manual and Technical Data Manual for the RC product. There are no special requirements above and beyond standard product application protocols.

### Hot aisle containment architecture

Simply follow APC InfraStruXure Designer Tool recommendations and rules along with all recommendations and requirements contained within the Installation Operation & Maintenance Manual and Technical Data Manual for the InRow RC product. It is required to select a fan speed preference of "Medium" or greater. There are no other special requirements above and beyond standard product application protocols.

### Rack air containment architecture

Simply follow APC InfraStruXure Designer recommendations and rules along with all recommendations and requirements contained within the Installation Operation & Maintenance Manual and Technical Data Manual for the InRow RC product. It is required to select a fan speed preference of "Medium" or greater. There are no other special requirements above and beyond standard product application protocols.

## Evidence of Compatibility

The HP c-Class chassis has been carefully tested and evaluated for compatibility with the APC InRow RC architecture. Specifically, the InRow RC deployed with RACS was used as the basis for evaluation.

To fully understand the behavior of the HP c-Class, four chassis were fully populated with a quantity of (16) BL460c blades each. Each blade was configured with: two Dual Core AMD Opteron™ 2.6 GHz 2218 Processors, 8 G DDR2 DIMM RAM, and two 36 G Hard Drives. Each chassis was fully populated with (10) fans and (6) 2,250 watt power supplies.

### Base line performance

Prior to testing in the RACS environment, a single fully populated chassis was bench tested in an environmental control chamber at 77°F using MaxCpu as the utility to exercise the CPUs from idle to full power. Full power is defined as both cores of both CPUs on each blade at 100% utilization within the specified zone of the chassis.

The data collected during testing included: multiple inlet temperatures at every blade position, exhaust temperature at each of the (10) cooling fans, wind tunnel airflow measurements, chassis power, power for each of the (10) cooling fans, and percent of maximum fan speed for each of the (10) cooling fans.

During the testing, a script was followed that dynamically adjusted the CPU utilization in each of the four chassis zones.

Table 1 – Baseline chassis testing

Test	Zone 1	Zone 2	Zone 3	Zone 4	Watts	Fan Speed	CFM
# 1	Idle	Idle	Idle	Idle	2,578	38%	400
# 2	Full	Idle	Idle	Idle	2,962	38%	393
# 3	Full	Full	Idle	Idle	3,408	38%	397
# 4	Full	Full	Full	Full	4,153	38%	388

The chassis was further evaluated with all zones at full power as well as all zones at idle power with 66°F used for an inlet temperature. The indicated fan speeds throughout these additional operating points held constant at 38% across all (10) fans.

The environment chamber was then ramped to 87°F inlet temperature to chassis with the fans remaining at a constant speed of 38% up to 86°F. Dynamic fan response was only observed above 86°F with a modest increase in fan speed from 38% to 43%. Zones 2 and 4 were then set to idle CPU utilization; the fans continued to operate at synchronized speeds.

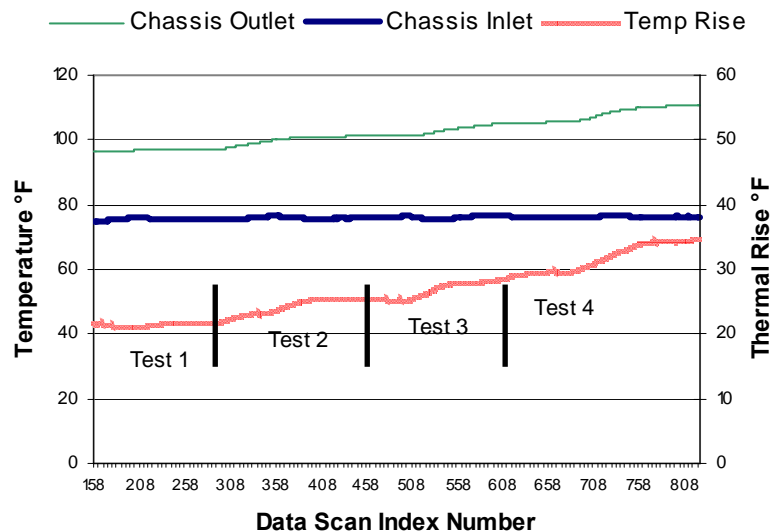
Finally, to determine maximum airflow potential, a failure of the on board administrator management card was simulated. The consequence being all (10) fans ramped to maximum speed with a resulting combined airflow of approximately 1,000 CFM. This reconciles well with the fan laws as:

Equation 1 – Fan law

$$CFM_2 = \frac{RPM_2}{RPM_1} * CFM_1$$

In this case,  $RPM_1$  and  $RPM_2$  are expressed in terms of percentage of maximum fan speed (38% and 100% respectively), with  $CFM_1$  being the average value of 395 from above table. The equation and data yield a calculated  $CFM_2$  value of 1,039 CFM versus the actual 1,000  $CFM_2$  measured. **Figure 2** shows temperature rise profile (yellow line) spanning Tests 1 through 4. The average server temperature rises after stabilization for each test being: Test 1 (21.5°F), Test 2 (25.3°F), Test 3 (28.8°F) and Test 4 (34.3°F).

Figure 2 – Baseline temperature profile



The chassis management scheme for the fans exhibited an absence of dynamic response while operating within the nominal inlet temperature range for the chassis. Analysis shows the chassis behavior to provide more or less constant airflow rate with variable temperature rise as a function of blade work load.

## RACS performance

Four identically configured chassis were populated into a 42U APC Netshelter SX Rack. The rack was augmented with both front and rear air containment kits and supported by a single RC operating with nominal water flow rate at a supply temperature of 45°F. The RACS performance was evaluated with the RC supply air temperature set at 72°F.

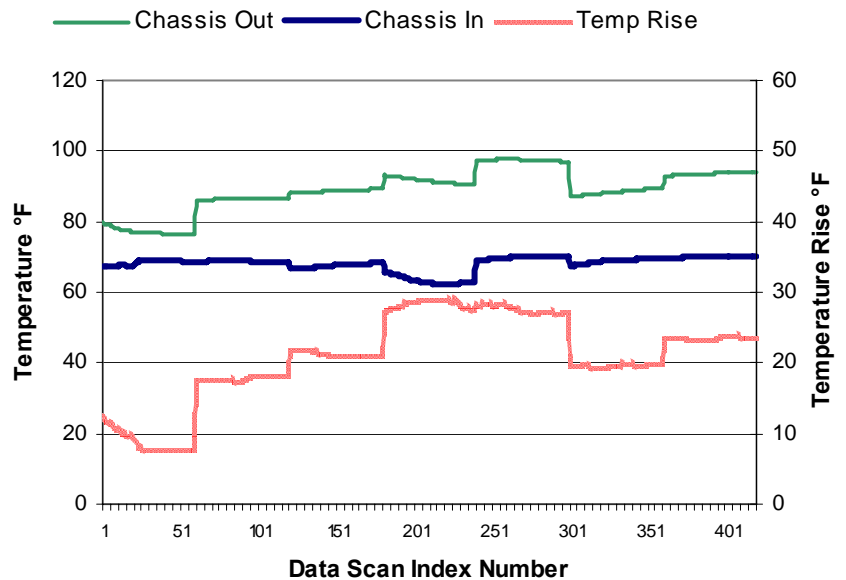
Given that the lowest observed temperature rise during baseline testing was slightly above 21°F, it is required to select a fan speed preference of “Medium” or greater when operating InRow RC units in either RACS or HACS. This may result in slightly more aggressive fan response than necessary, but the chassis will always be assured adequate airflow and elimination of possible back pressures within hot air containment volumes.

The data collected during testing included: inlet temperatures at each of the four zones for all four chassis, exhaust temperature at each of the (40) cooling fans, power consumed by each of the chassis, power for all (40) cooling fans, percent of fan capacity for all (40) cooling fans, InRow RC chilled water flow rate, InRow RC fan speeds, RC supply air temperature, RC return air temperature, RC chilled water valve position, IRC chilled water supply temperature, and RC chilled water return temperature.

During the testing a script was followed that dynamically adjusted the power level of the four chassis under evaluation. There was no appreciable difference in chassis behavior from the baseline testing including but not limited to: thermal temperature rise across chassis and fan operating speeds.

The testing within the RACS configuration had an average maximum temperature rise across all four chassis of 30°F (**Figure 3**), slightly less than compared to the bench mark testing of about 34°F. Equally important the worst case chassis temperature rise was only 37°F versus 35°F for the benchmark testing. The modest differences of temperature rise values are well within expected tolerances for instrumentation and do not represent any meaningful change to the chassis thermal or airflow environment.

*Figure 3 – RACS temperature profile*



## Conclusions

The InRow RC product performed well with the HP c-Class configuration that was evaluated. The specific configuration used is assumed to reasonably represent the behavior of chassis using alternate configurations. However, there are a couple of considerations the user should keep in mind.

*Table 2 – Fan sensitivity settings*

Expression	$\Delta^{\circ}\text{F}$
High	10
Medium-High	15
Medium	20
Medium-Low	25
Low	30

The InRow RC control algorithm, operating in HACS or RACS, attempts to determine required airflow against the user selected fan sensitivity adjustments. While the choices are described using relative qualifiers, (high, medium-high, medium, etc...) the relative terms actually map to values for the temperature differences to be maintained across the supply and return of the cooler. The qualifier expressions used relates to the fan speed consequence rather than the temperature difference maintained. This is to say the choice of "High," while attempting to maintain the smallest temperature rise, will do so by using the greatest fan speed per unit of energy removed.

The only consequence of this control strategy is the InRow RC attempts to move more air than is necessary during normal chassis operation as the power dissipation from servers is increased. The net result being a small amount of leakage air is expected to be exchanged between the InRow RC and surrounding environment. Conversely, should the chassis enter abnormal operating condition, management card failed, etc..., the InRow RC, upon detecting lower temperature rise, will reduce its fan speed. The net result being a small amount of leakage air is expected to be exchanged between the chassis and the surrounding environment. The user may minimize risk and magnitude of the latter by selecting more aggressive fan response to load (high, or medium-high). Should the user select a more aggressive fan response to load, an even greater exchange of air between the cooler and environment should be expected. The additional benefit of this strategy is the cooler may also provide some level of incremental cooling for the adjacent environment.

***Ultimately, the InRow RC should be considered an excellent companion to the HP c-Class chassis, easily handling the thermal challenges produced!***

### About the Author:

**John Bean Jr.** is the Director of R&D for Cooling Solutions at American Power Conversion. Previously John was the World Wide Engineering Manager for Cooling Solutions at APC, developing several new product platforms and establishing engineering and laboratory facilities in both the USA and Denmark. Before joining APC, John was the Engineering Manager for other companies involved in the development and manufacture of mission critical cooling solutions.